Construction safety in the repair and maintenance sector

A.P.C. Chan, F.K.W. Wong, M.C.H. Yam, D.W.M. Chan, C.K.H. Hon
Construction Safety Research Group, Research Centre for Construction and Real Estate Economics, Department of Building and Real Estate, The Hong Kong Polytechnic University, HKSAR, China

D. Dingsdag
Senior Lecturer, University of Western Sydney, Australia.

H. Biggs
Associate Professor, Queensland University of Technology, Australia.

ABSTRACT: Statistics indicate that the percentage of fatal industrial accidents arising from repair, maintenance, minor alteration and addition (RMAA) works in Hong Kong was disturbingly high and was over 56% in 2006. This paper provides an initial report of a research project funded by the Research Grants Council (RGC) of the HKSAR to address this safety issue. The aim of this study is to scrutinize the causal relationship between safety climate and safety performance in the RMAA sector. It aims to evaluate the safety climate in the RMAA sector; examine its impacts on safety performance, and recommend measures to improve safety performance in the RMAA sector. This paper firstly reports on the statistics of construction accidents arising from RMAA works. Qualitative and quantitative research methods applied in conducting the research are discussed. The study will critically review these related problems and provide recommendations for improving safety performance in the RMAA sector.

1 INTRODUCTION

Safety has been recognized as one of the besetting problems with the Hong Kong construction industry. The Hong Kong Construction Industry Review Report (HKCIRC 2001) highlighted safety to be one of the six major areas for improvement. With shrinkage of the construction market and reduced volume of new works, repair, maintenance, minor alteration and addition (RMAA) works are playing an increasingly important role in the local construction industry. RMAA works refers to those minor works such as construction projects for village-type houses in the New Territories, minor alterations, repairs, maintenance and interior decoration of existing buildings (Labour Department 2008b). Research on safety performance of RMAA works, however, has been rather limited.

1.1 *RMAA works in the construction industry*

The construction industry contributed 2.7% to the GDP (at current factor cost) of Hong Kong in 2006 (Census and Statistics Department 2008a). The number of persons directly engaged in the construction industry was 135,337 in 2006 (Census and Statistics Department 2008b). For the types of construction activities, construction work in RMAA is coming more and more important as it contributed to 53.2% of the total construction market in 2007. As shown in Table 1, the proportion of RMAA works to total construction market has been doubled from 1997 to 2007. Importance of RMAA works to the whole construction industry is expected to increase continuously in the foreseeable future. To counteract the disastrous effect of the global financial crisis to the construction industry, the HKSAR Government is trying to assist the construction industry by launching more minor works to create immediate employment opportunities (Development Bureau, HKSAR 2008). The Development Bureau of the HKSAR has just announced that HK$ 8.56 billion (approx. US$ 1.10 billion) will be spent on minor works in 2009/2010 to create 1600 jobs. The projects include refurbishment of the exterior of 50 government buildings, renovation of aged protective surfaces of 500 slopes, the installation and retrofitting of energy-efficient facilities for various government departments, and provision of green roofs on 40 government buildings (The Standard on 14 January 2009).

Table 1. Gross value of construction work at current market prices (1997 -2007)

(Unit: HK$ million at current prices; US$1= HK$ 7.8)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Residential (A)	36,633	48,761	56,225	51,920	41,774	36,503	28,612	20,085	16,945	15,518	16,064
Non-residential (B)	32,392	33,866	20,455	17,407	16,026	16,502	18,243	17,425	17,060	14,161	17,289
Civil Engineering (C)	29,957	19,349	16,873	20,583	24,491	21,358	20,710	19,044	14,686	12,311	10,123
Total Construction Investment (A+B+C)	98,982	101,975	93,553	89,910	82,290	74,362	67,564	56,553	48,691	41,990	43,476
Repair, Maintenance, Minor alteration and Addition (D)	32,518	31,341	32,884	32,161	31,696	31,638	31,468	36,618	42,160	48,240	49,390
Total Construction Market (A+B+C+D)	131,500	133,316	126,437	122,071	113,986	106,000	99,032	93,171	90,851	90,230	92,866
Percentage of RMAA Works to Total Construction Market (%)	24.7	23.5	26.0	26.3	27.8	29.8	31.8	39.3	46.4	53.5	53.2

(Source: Report on the Quarterly Survey of Construction Output, Table 1A and Table 3, C&SD, The HKSAR Government)

Table 2. Industrial accidents of the construction industry

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
(a) All reported construction accidents**	19,588 (56)	14,078 (47)	11,925 (29)	9206 (28)	6239 (24)	4367 (25)	3833 (17)	3548 (25)	3400 (16)	3042 (19)
(b) Accident rate per 1000 workers	247.9	198.4	149.8	114.6	85.2	68.1	60.3	59.9	64.3	60.6
(c) All reported accidents in RMAA Works**	3510 (7)	3328 (10)	3402 (12)	2582 (4)	1925 (10)	1485 (8)	1454 (6)	1509 (12)	1697 (9)	1524 (6)
(i) No. of reported accidents in RMAA Works in public sector sites**	466 (0)	449 (3)	475 (1)	331 (2)	250 (2)	158 (2)	104 (0)	64 (2)	60 (5)	50 (1)
(ii) No. of reported accidents in RMAA Works in private sector sites**	3044 (7)	2879 (7)	2927 (11)	2251 (2)	1675 (8)	1327 (6)	1350 (6)	1445 (10)	1637 (4)	1474 (5)
Percentage of RMAA accidents to all reported construction accidents [(c)/(a)]	17.9%	23.6%	28.5%	28.0%	30.9%	34.0%	37.9%	42.5%	49.9%	50.1%

*** Figures in the brackets denote the number of fatalities.*

(Source: Labour Department HKSAR (2008b) Accidents in the Construction Industry of Hong Kong (1998-2007))

1.2 *Safety performance of RMAA works*

Referring to Table 2, safety performance of the construction industry has been improved tremendously. Accident rates per 1000 workers fell from 247.9 in 1998 to 60.6 in 2007, representing a remarkable drop of 75.6% (Labour Department 2008b). However, we should note that the accident rate per 1000 workers has reached a plateau after 2003. The challenge to the industry would be how to further drive down accident rates to achieve continuous improvement in safety performance.

It is noteworthy that there has been a remarkable increase in the percentage of accidents on RMAA worksites over the past ten years, from 17.9% of 1998 to 50.1% of 2007. Admittedly, this change may be due to the increase in proportion of RMAA works to the whole construction industry; however, it still provides a valid ground for our investigation on safety of RMAA worksites.

1.3 *Safety climate*

Zohar (1980) defined safety climate as ‘a summary of molar perceptions that employees share about their work environments… a frame of reference for guiding appropriate and adaptive task behaviors’ (p.96). Griffin and Neal (2000) suggested that employees’ perceptions of the policies, procedures, and practices relating to safety comprise the safety climate. As stated by Zohar (2003), safety climate reflects the true perceived priority of safety in an organization. Some researchers define safety climate as a current-state reflection of the underlying safety culture (Mearns et al. 2001, 2003).

Zohar (2003) separated safety climate into two dimensions: level and strength. The level of safety climate reflects shared perceived priority of safety whereas strength of safety climate is homogeneity of perceptions of the importance of safety. Safety systems and polices do not automatically generate safety; it is the true priority of safety that is consensually perceived by people that affects their safety behavior. For example, a company has imposed overt safety policies and management systems; however, when safety and time come into conflict, the manager gives the message that time overrides safety. People inside the organization will project a low priority for safety, i.e. a low level of safety climate.

Safety climate influences one's behavior through behavior-outcome expectancies (Zohar 2003). Low safety climate implies that people assign lower weight to safety but greater value to short-term gains, e.g. finishing the work faster. Under a low safety climate, people also underestimate the likelihood of possible injury. It is believed that expectancies influence prevalence of safety behavior which in turn influences company safety performance.

1.4 *Significance and value*

This study aims to investigate the causal relationship between safety climate and safety performance of RMAA works. As supported by statistics, safety legislation and related policies can effectively drive down accident rates to a certain level, but these will reach a plateau sometime. This tendency is reflected in other developed industrialized societies, notably Australia where current research shows that legislative compliance on its own is not sufficient for continuing reduction in incidence and severity. For example, in the State of NSW, Australia, compensated manual handling injuries were consistently within the 30-35 percent of total compensated injuries between 1997/98 and 2006/07, notwithstanding that the overall number of compensated injuries has fallen over the last decade or so (WorkCover 2007). It is believed that positive safety culture is a possible way to further improve safety performance. This research on safety climate will contribute to providing insightful ways on how to change people's safety behaviors.

Besides, safety climate is a prevalent issue that interests practitioners in the construction industry. The Occupational Safety and Health Council (OSHC) of the HKSAR has recently developed and promoted the Safety Climate Index (SCI) to the industry. SCI is a survey tool for measuring level of safety climate. Industry practitioners have practical reasons to know more about safety climate so as to make better use of safety climate scores. Examples include the meaning of high/ low levels of safety climate, implications to organizational policies and management, the way to further improve safety performance and to create safe working environments.

2 OVERALL RESEARCH FRAMEWORK

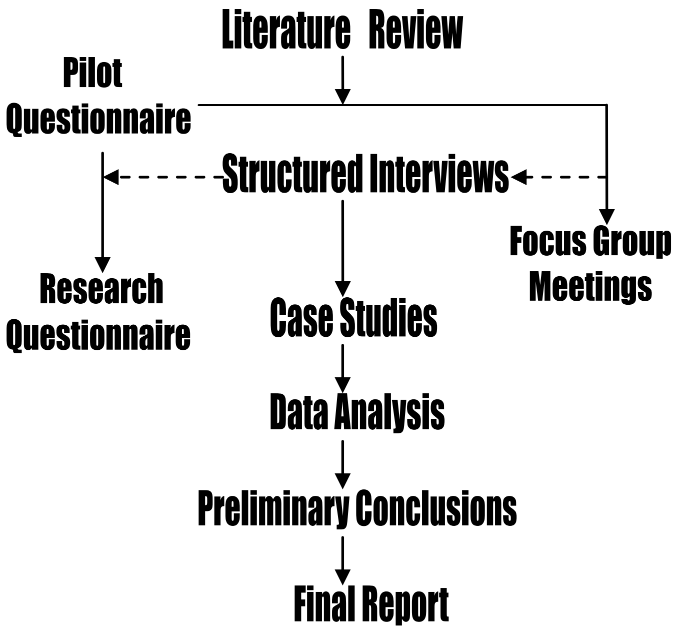

Figure 1. Overall research framework for the study

2.1 *Literature review*

To begin the study, a systematic literature review has been done on keywords like safety climate, safety culture and safety performance in two academic electronic databases, *ISI Web of Knowledge* and *Scopus*. A total of 78 articles were identified in *ISI Web of Knowledge* and 38 articles were identified in *Scopus*, confirming results of each other. Seven key journals have been identified as well. Follow up searches were done on individual journals and reference lists of individual papers. Another search was done on top-tier journals in the construction industry.

2.2 *Questionnaire Survey*

A questionnaire survey instrument is an effective method to seek a large sample size for quantitative data analysis (Hox et al. 2008). The survey instrument will focus on identifying the relationships between the safety climate factors and safety performance. A safety climate survey tool, Safety Climate Index (SCI), developed by the Occupational Safety and Health Council, HKSAR (OSHC, 2008) will be employed and supplemented with other relevant questions. Comments gained from the pilot questionnaire will be incorporated to refine the research questionnaire.

RMAA contractors listed under the Hong Kong General Building Contractors' Association, the Voluntary Subcontractor Registration Scheme, and the Census & Statistics Department will be invited to participate in this questionnaire survey. It is likely that the responses on the safety climate factors may be affected by their working position hence the respondents will be stratified according to their organizational status, namely, managerial, supervisory and site workforce. At least 100 samples from each of these organizational levels will be obtained to ensure a valid analysis.

2.3 *Structured interviews*

Ten structured interviews will be conducted, including both large and small scale contractors which undertake RMAA works. Ten questions have been set to capture experienced practitioners' perceptions on the causes of accidents, current safety practices of RMAA works and their implementation obstacles. These questions are in place to achieve the primary purpose of getting a holistic view of the safety practices in the RMAA sector. Interviewees will be asked to assess the safety climate of their company on RMAA works by giving ratings from 1 to 5 on seven prescribed safety climate factors.

2.4 *Case studies*

To gain an in-depth understanding of the causes of accidents in the RMAA sector, fatal accidents in RMAA works will be selected and analyzed. These cases will be analyzed for common features, characteristics, failures and problems. Major factors studied include:

- Time and date of accident – to detect if there is any noticeable pattern in terms of time, day of a week, month and season that RMAA accidents may happen.
- Age of victim – to detect if a certain age group is more prone to RMAA accidents. Other demographics such as gender, cultural origin; i.e. Mainland China/ Nepal, level of education/ literacy will also be studied.
- Trade of worker – to detect if there are any traceable trades which are more prone to RMAA accidents.
- Length of experience – to detect if the length of experience affects RMAA accidents.
- Place of accident – to study whether there are any common locations resulting in RMAA accidents.
- Agency involved – to detect if there are any agents such as certain types of tools or technical processes which are more likely to be involved in RMAA accidents.
- Type of work involved – to detect if there are any types of work which are more prone to RMAA accidents.
- Unsafe condition/action – to study whether there are any common unsafe conditions/actions resulting in RMAA accidents.
- Safety education and training – to trace whether the victims have received any safety education and training prior to RMAA accidents.
- Use of safety equipment – to determine whether the victims have used any safety equipment in RMAA accidents.
- Employment terms and conditions – to identify whether the mode of employment (e.g. permanent, day or hourly labour) affects RMAA accidents.

2.5 *Focus group meetings*

Focus group meetings will be organized to solicit RMAA safety related information from a much wider audience. This is particularly important for RMAA works because most of these projects are carried out by contractors of small to medium scale. Vaughn et al. (1996) asserted that focus groups should possess two core elements: (1) a trained moderator who sets the stage with prepared questions or an interview guide; and (2) the goal of eliciting participants' feelings, attitudes and perceptions about a selected meeting. At least four focus group meetings will be organized in this study: two for the RMAA supervisory and management staff, and two for front-line RMAA workers.

Each focus group will be moderated by a research team member, who will first make a short presentation on the RMAA accident statistics and setting the stage with prepared questions. The participants will then be divided into groups of six to ten to sustain lively and active discussion. Other research team members will be assigned to sit in each group to trigger discussions and responses. Each group will then be asked to nominate a rapporteur to present the group's findings and recommendations at the end of the meeting.

3 DATA ANALYSIS

Advanced statistical techniques such as Factor Analysis and Multiple Linear Regression Analysis will be applied to analyze the raw data obtained from the questionnaire survey to identify the impacts of safety climate on safety performance in the RMAA sector.

Factor Analysis is a statistical technique used to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables (Hair et al. 2006). Principal factor extraction with promax rotation will be performed through SPSS FACTOR program on the safety climate attributes. The purpose of this test is to compute the degree of item loading on their corresponding factors. The chi-square test statistic of Bartlett's Test of Sphericity will also be performed to test whether the correlations are significantly different from zero.

Multiple Linear Regression (MLR) Analysis is considered as the most suitable technique to derive the relationships between the variables (Hair et al. 2006). The relative influence of the safety climate factors on the safety performance of RMAA projects extracted from factor analysis will be explored by multiple stepwise regression analysis.

A stepwise selection procedure with a significance level of 5% will be used to select statistically significant variables to be incorporated into the model. Data variables will be added one at a time and the regression model re-run noting the changes at each step in the coefficient of determination (R^2) value and, more importantly, the significance level of variables.

Only those variables with a *P-value* of less than 10% will be included in the final regression equations. The coefficient (R^2) indicates how much variation in the dependent variable is explained by a group of independent variables; and the higher its value, the more powerful the model. Adjusted R^2, which attempts to more realistically reflect the goodness of fit of the model, will be used to compare and identify the best-fit regression model.

4 VALIDATION OF THE RESULTS

Research data and analyses will be triangulated from multiple sources to help improve the credibility of the findings. Results derived from the questionnaire survey, structured interviews, focus group meetings and case studies will be cross-referenced to complement each other. Workshops will be used to discuss (preliminary) conclusions with industry practitioners involved in the study to help understand the relevance of the findings in the context of changing circumstances over the period studied. Three workshop sessions have been included in the research programme.

5 CONCLUSIONS

To conclude, this paper has briefly illustrated the research framework of how to investigate the relationship between safety climate and safety performance of the RMAA sector. The research team expects that RMAA works will become more and more important to the local construction industry. Their safety problems have to be tackled if we would like to see a continuous improvement in safety performance of the construction industry. Previous research, existing safety management systems and legislation, and plateauing reductions in injury and fatality rates, suggest that we can do little else to drive down accident rates. It is proposed that developing a positive safety climate is one of the effective ways to improve safety performance. A positive safety climate should lead to increasing safe behaviors and in turn improve safety performance. In this study, this proposition will be tested by looking at whether safety climate affects people's safe behaviors and then propose effective safety measures and recommendations to the industry for consideration of implementation.

6 ACKNOWLEDGEMENT

The work described in this paper is fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (RGC Project Ref. No. B-Q05M)

7 REFERENCES

Census and Statistics Department, HKSAR. 2008a. *Gross Domestic Product (GDP) by Economic Activity - Percentage Contribution to GDP at Current Factor Cost (Table 036).* http://www.censtatd.gov.hk/hong_kong_statistics/

Census and Statistics Department, HKSAR. 2008b. *Report on 2006 Annual Survey of Building, Construction and Real Estate Sectors.* Census and Statistics Department, HKSAR Government. http://www.censtatd.gov.hk/hong_kong_statistics/

Development Bureau, HKSAR. 2008. *Immediate measures proposed to assist construction industry.* Publications and Press Releases on 25 November 2008. http://www.devb.gov.hk/en/secretary/press/press20081125a.htm

Griffin, M.A. & Neal, A. 2000. Perceptions of safety at work: A framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of Occupational Health Psychology* 5(3): 347-358.

Hair, J.F., Anderson, R.E., Tatham, R.L. & Black, W.C. 2006. *Multivariate Data Analysis.* Upper Saddle River: Prentice Hall.

Hong Kong Construction Industry Review Committee. 2001. *Construct for excellence.* Report of the Construction Industry Review Committee, Hong Kong SAR.

Hox, J.J., de Leeuw, E.D. & Dillman, D.A. 2008. The cornerstones of survey research. In E.D. de Leeuw, J.J. Hox & D.A. Dillman (eds), *International Handbook of Survey Methodology:* 1-17. USA: Taylor and Francis Group.

Labour Department, HKSAR. 2008a. *Occupational Safety and Health Statistics 2007*. Occupational Safety and Health Branch, Labour Department, HKSAR Government.

Labour Department, HKSAR. 2008b. *Accidents in the Construction Industry of Hong Kong (1998-2007).* Occupational Safety and Health Branch, Labour Department, HKSAR Government.

Mearns, K. Whitaker, S.M. and Flin, R. 2001. Benchmarking safety climate in hazardous environments: A longitudinal, interorganizational approach. *Risk Analysis* 21(4): 771-786.

Mearns, K. Whitaker, S.M. and Flin, R. 2003. Safety climate, safety management practice and safety performance in offshore environments. *Safety Science* 41(8): 641-680.

Occupational Safety and Health Council, HKSAR. 2008. *Construction Industry Safety Climate Index Software*.

The Standard (14 January 2009). Hong Kong, *Kai Tak takes off.*

Vaughn, S., Schumm, J.S. & Sinagub, J. 1996. *Focus Group Interviews in Education and Psychology*. United States: Sage Publications.

WorkCover**,** New South Wales. 2007. *New South Wales Workers Compensation Statistical Bulletin 2006/07*.

Zohar, D. 1980. Safety climate in industrial ogranizations: Theoretical and applied implications. *Journal of Applied Psychology* 65(1): 96-102.

Zohar, D. 2003. Safety climate: Conceptual and measurement issues. In J.C. Quick & L.E. Tetrick (eds), *Handbook of Occupational Health Psychology*: 123-142. Washington, D.C.: American Psychological Association.